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EXPERIMENTAL STUDY OF A DIELECTRIC ANTENNA AT THE  
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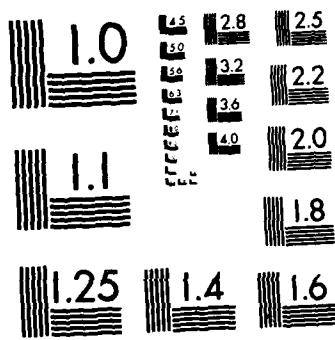
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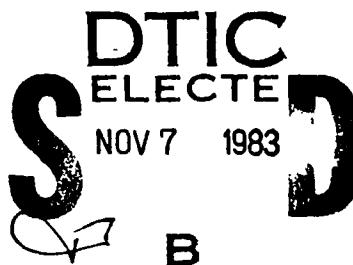
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A. Chang  
R. Mittra

October 1983

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DEPARTMENT OF ELECTRICAL ENGINEERING  
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The study of the shape and transition of an antenna at high frequency is a fundamental problem to be considered in its design if a reasonable performance is to be expected. Some experimental results are given regarding shape and transition at 76-80 GHz.		

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by

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## I. INTRODUCTION

The utilization of higher frequencies (s.h.f. or e.h.f. range) in the millimeter-wave integrated circuits has been of a constant interest to designers in this field. In designing an antenna which is useful in the microwave frequencies, the application of dielectric materials to improve the gain-radiation characteristic is becoming a common practice. However, the problems concerning the shape of a dielectric antenna and the transition from the metal waveguide to the antenna need careful attention if its maximum effectiveness is to be achieved. A dielectric wedge-shaped waveguide antenna at 8.5-11.5 GHz frequency range has been investigated recently [1]. In this report the usefulness of the wedge-shaped antenna at the higher frequency range of 76-80 GHz is examined. Other shapes than the wedge together with various transition types are considered. At millimeter wavelengths, it is desired to devise a transition which is as short as possible and with an acceptably small insertion loss. Thus, whenever transition is concerned, special attention has been paid to achieve these criteria. The dielectric material used is rexolite.

## II. EXPERIMENTS ON THE TRANSITIONS OF ANTENNA

Figure 1 shows the shapes and the terms used to describe a particular shape. One surprising result obtained from experimenting with various types of transitions is the fact that the types of tapering or even the length of the transition affect the antenna pattern very little, if any at all. Refer to Fig. 2 and Fig. 3 for the patterns taken for wedge-shaped transition and abrupt transition, respectively, as the length ( $L_t$ ) is varied. While  $L_t$  changed, the parameters  $L_a$  and  $L_w$  were kept constant for each case. Contrary to the usual thought and some other experiments performed earlier which showed the effect of transition [2] on the gain-radiation pattern, the experiment has shown that, regardless of the type and length of the transition from metal waveguide to the antenna, it is possible to obtain almost identical gain-radiation patterns provided that the parameters  $L_a$  and  $L_w$  are kept constant—at least, at the frequency range of 76-80 GHz. It is quite interesting to see that not only do we not need a smooth transition but need to have just enough  $L_t$  to attach the dielectric antenna to the waveguide so that it will adhere to it.

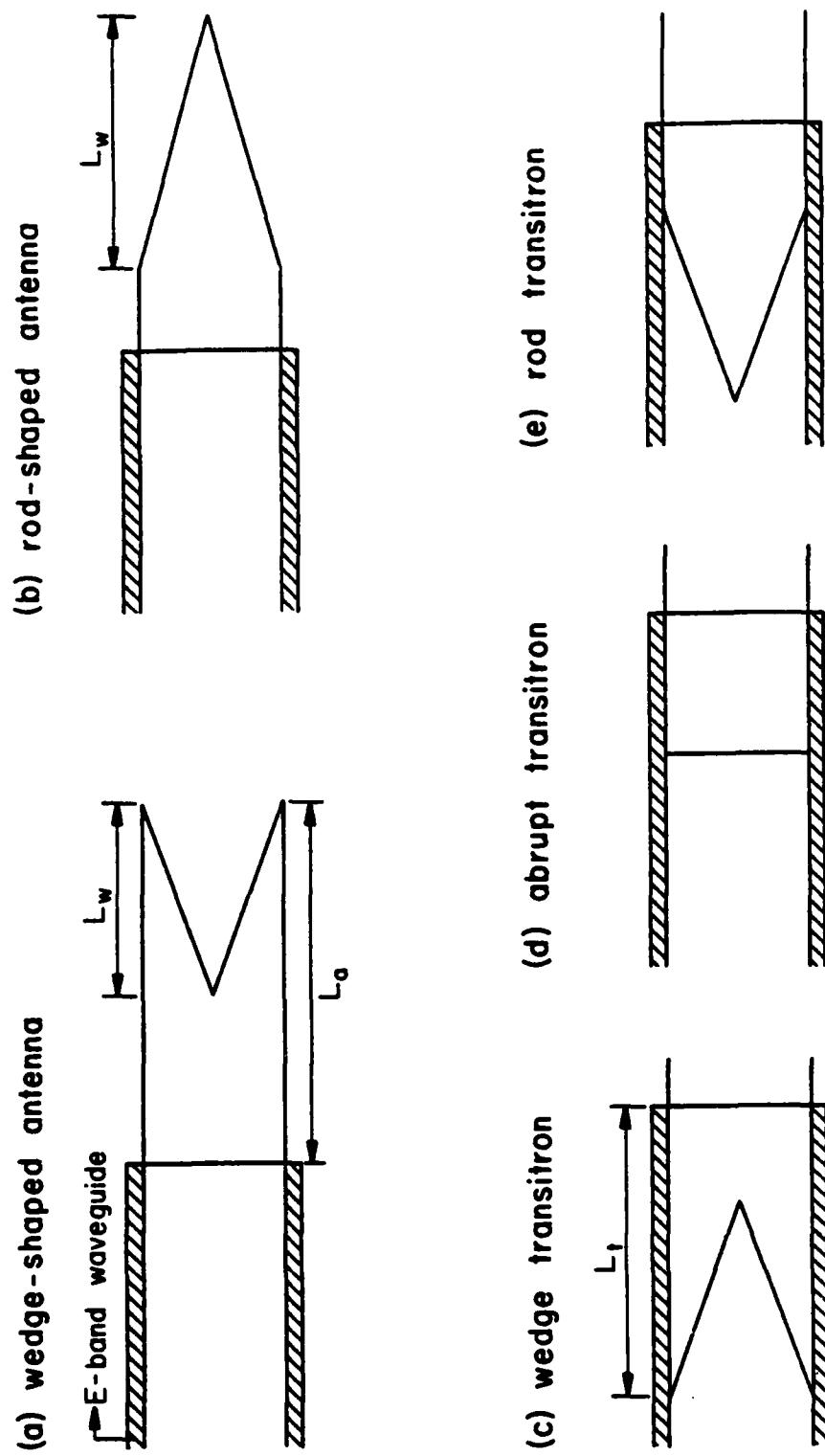


Figure 1 H-plane view.

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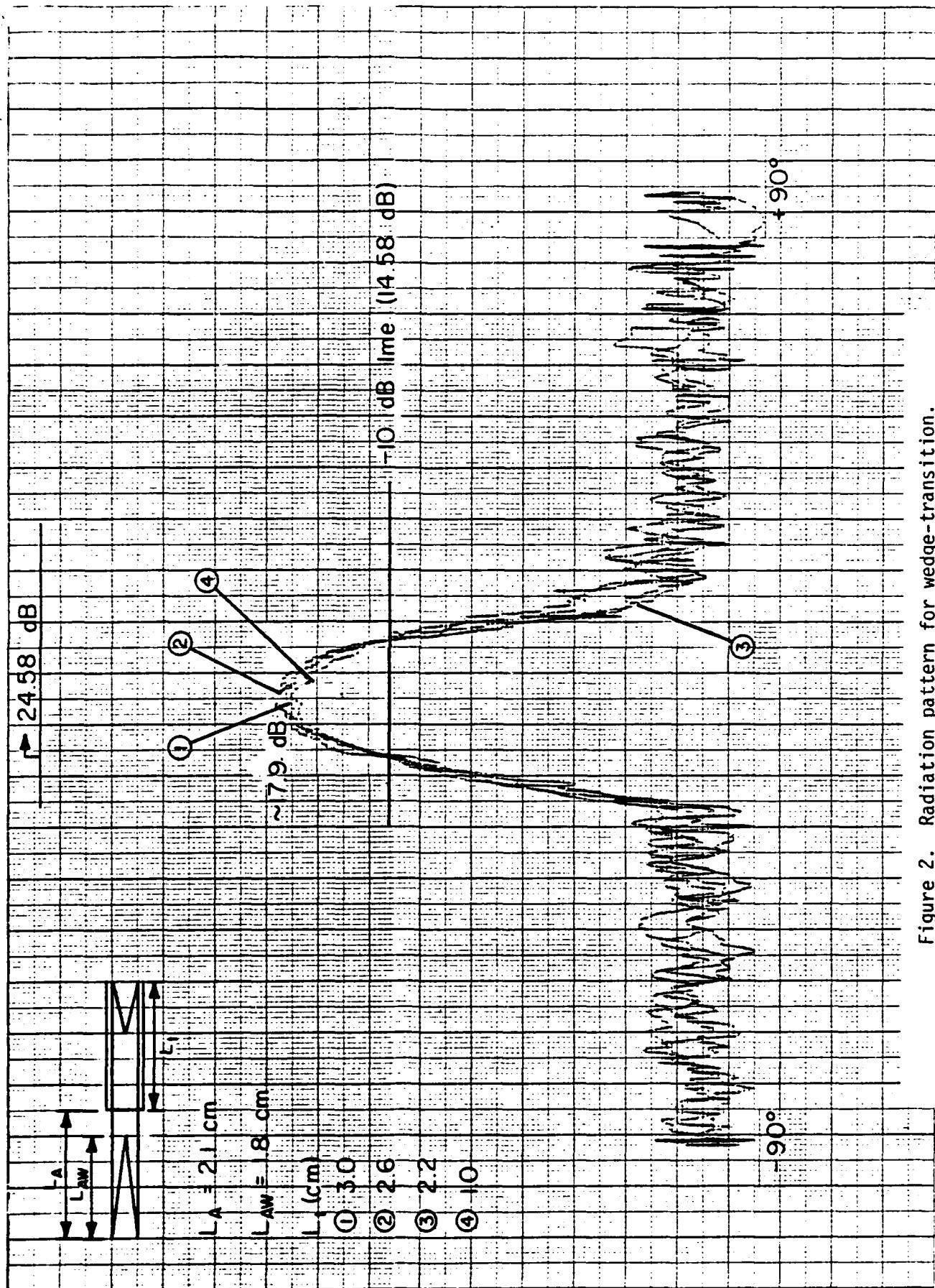


Figure 2. Radiation pattern for wedge-transition.

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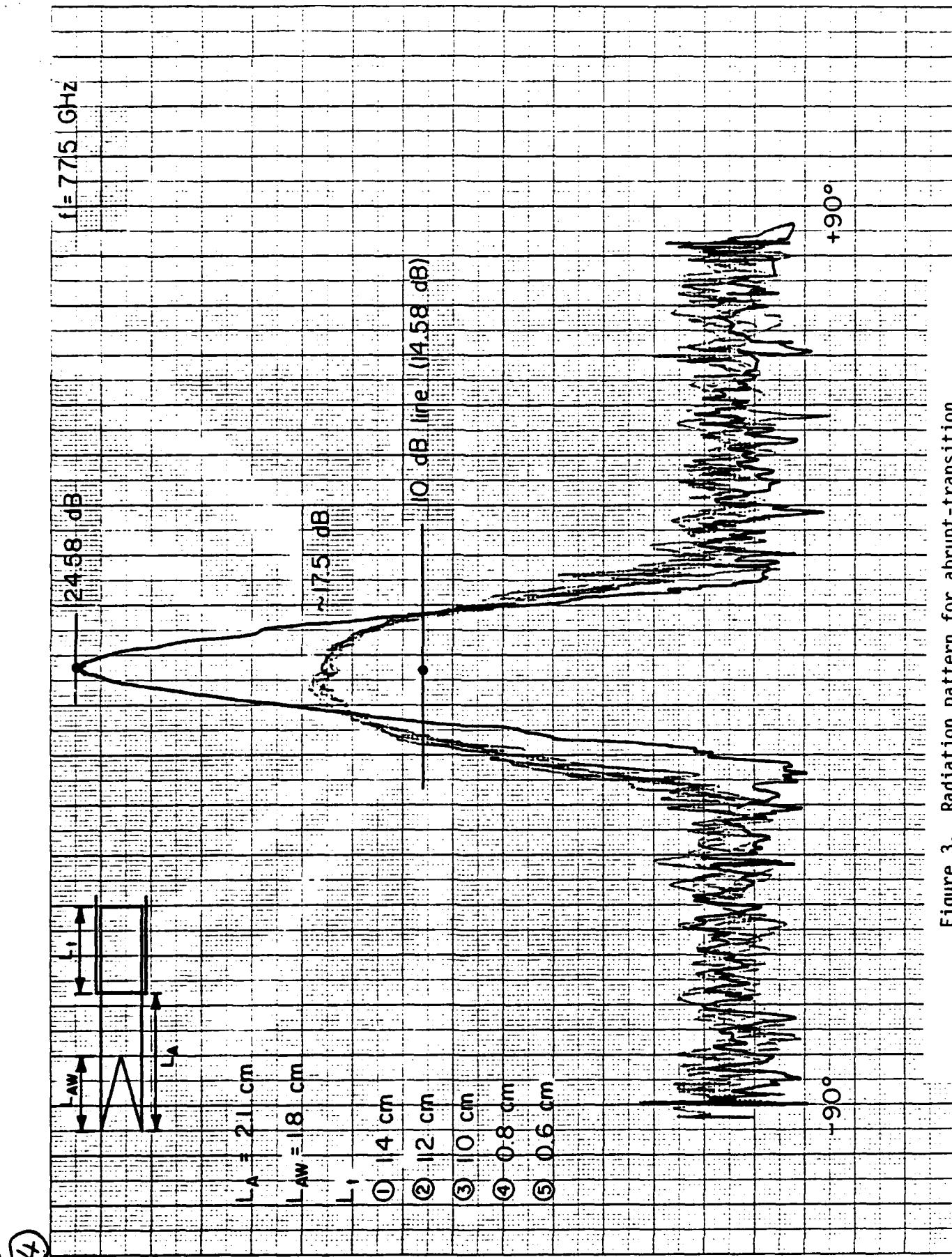


Figure 3. Radiation pattern for abrupt-transition.

### III. EXPERIMENTS ON THE SHAPES OF ANTENNA

Unless indicated explicitly otherwise, the patterns are made in the H-plane. But the experiment performed in the E-plane has shown that E-plane patterns have similar gain-radiation characteristics to those in the H-plane.

Having established the fact that the transition has little influence, it has been verified that the antenna patterns are just about the same whether it be a wedge-shaped or a rod-shaped antenna. Refer to Fig. 4. But the experiment indicates that the relative lengths of  $L_a$  and  $L_w$  are the factors to determine the gain and the half-power beamwidth characteristics of each type under examination. After many trial-and-error types of experiments, it was found that the difference  $L_a - L_w$  should be about  $1.5\lambda$  or less to obtain reasonably good gain characteristics.

As the frequency changes over the 76-80 GHz range, the radiation pattern shows a slight but not too significant difference (usually within 0.5-1.0 dB difference over the 76-80 GHz range).

As for the shape chosen for the antenna, it is of some interest to a designer to know how the shape affects the pattern. Experiments were performed for this purpose at 77.5 GHz. The results are quite interesting. Various types which may be considered arbitrary are shown, together with the patterns obtained, in Fig. 5. Notice that as long as the antenna is essentially "straight" and the difference  $L_a - L_w$  is within approximately 1.0 to  $1.5\lambda$ , roughly, the gain characteristic is good enough to match

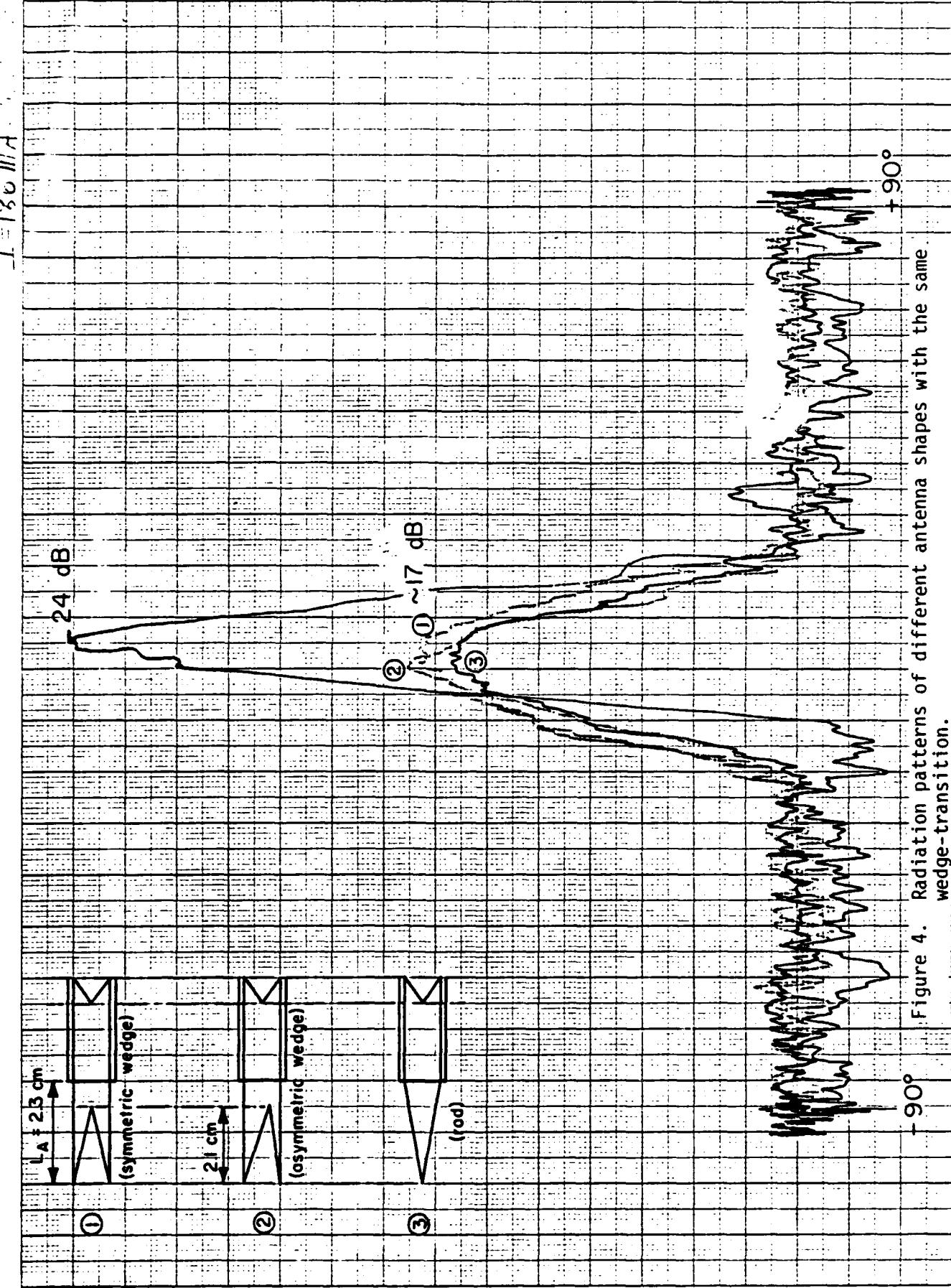


Figure 4. Radiation patterns of different antenna shapes with the same wedge-transition.

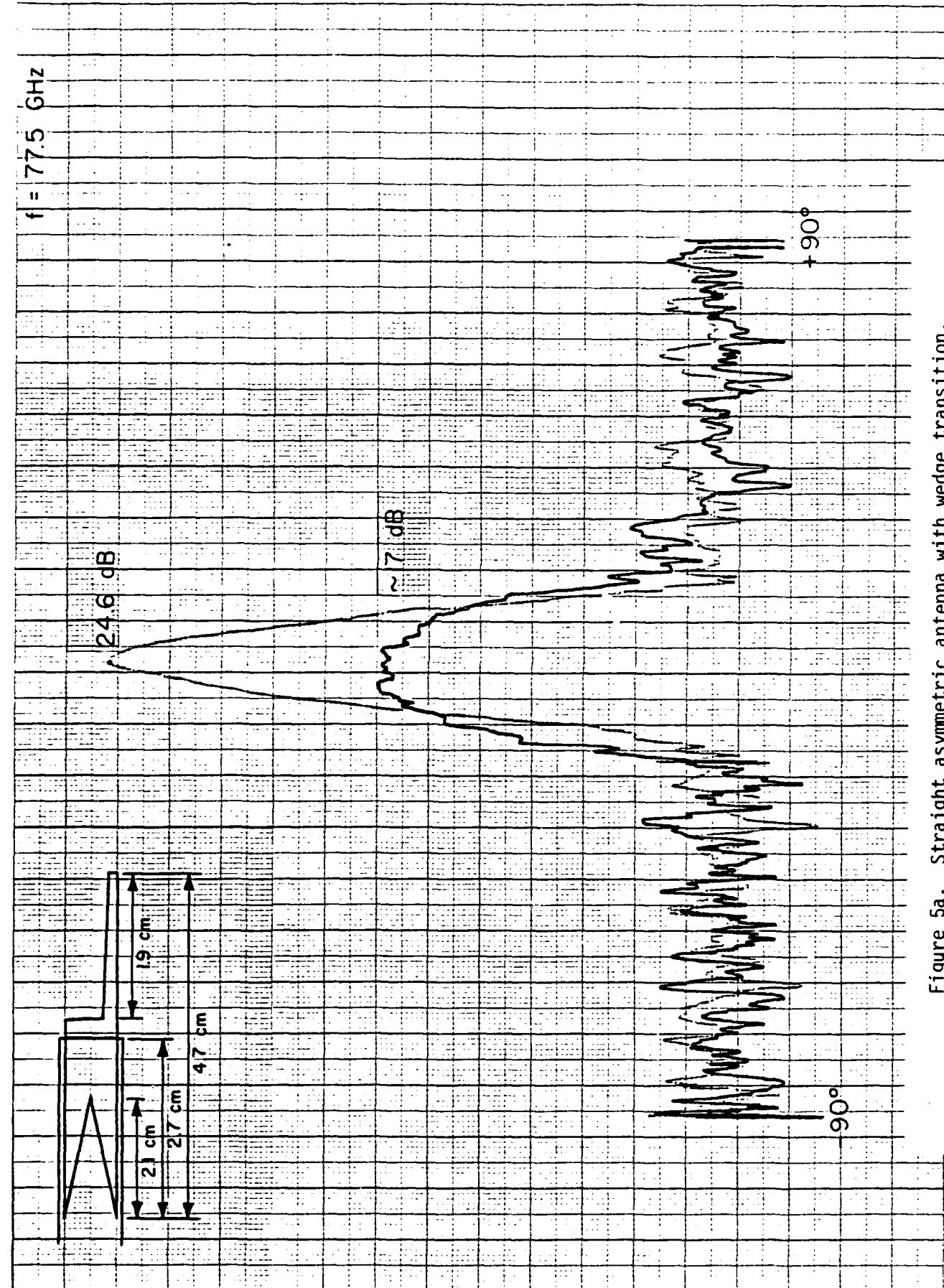


Figure 5a. Straight asymmetric antenna with wedge transition.

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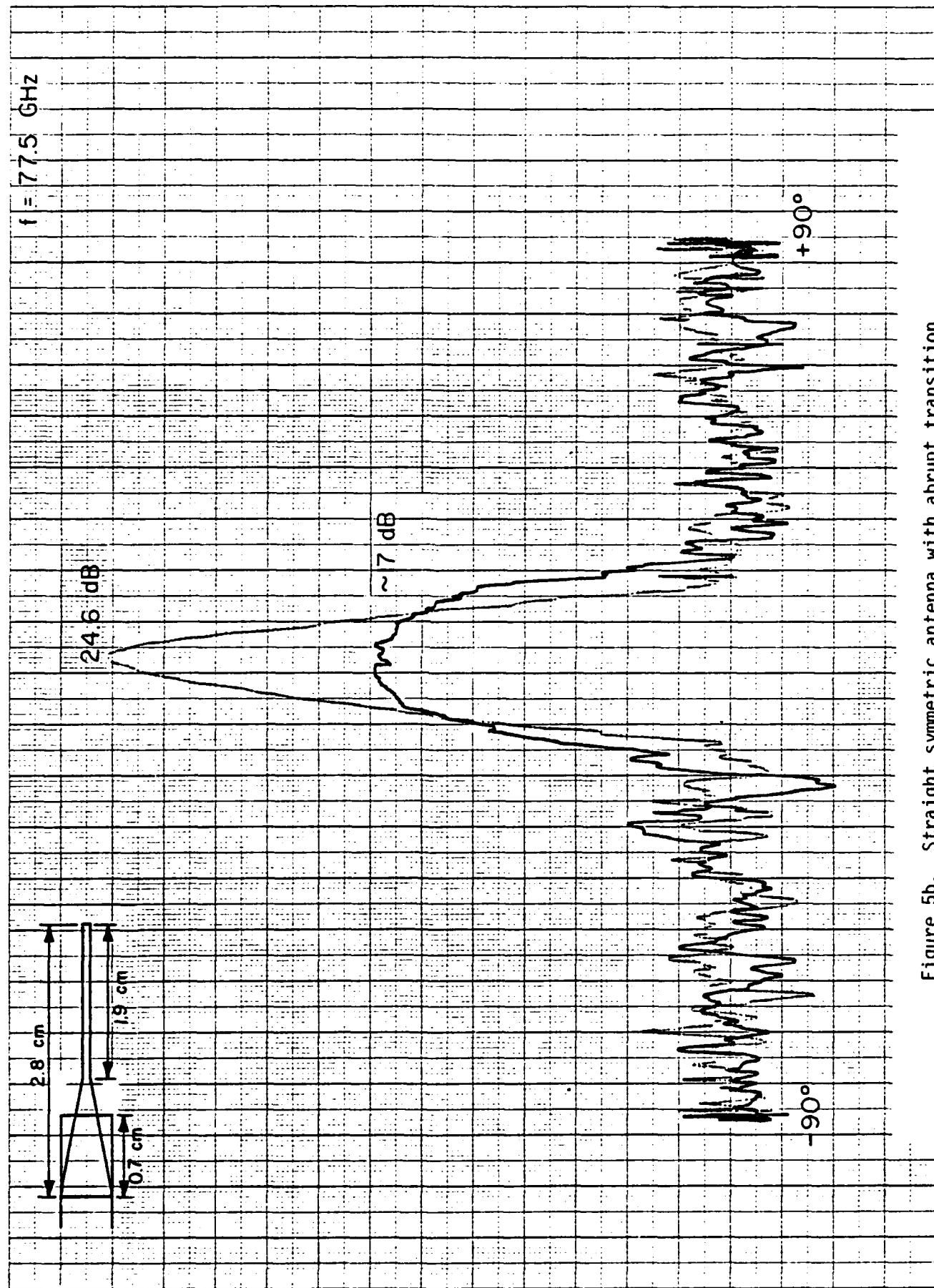


Figure 5b. Straight symmetric antenna with abrupt transition.

the patterns obtained from well-made, symmetric antennas. Thus, it is quite doubtful if a specific shape must be used to obtain a reasonable performance of a dielectric antenna at the frequency range of 76-80 GHz.

#### IV. CONCLUSION

Shapes of a dielectric antenna and its transition to the metal waveguide were examined to obtain the maximum effectiveness of the antenna. It is found that "any" type of transition is fine with "any" length. To obtain a reasonable pattern, i.e., good gain and HPBW, the shape of the antenna could be quite arbitrary, as long as certain requirements for  $L_a$  and  $L_w$  are met. The usual gain obtained is around 16 dB and HPBW of 20-25 degree.

#### REFERENCES

- [1] K.K.S. Jamwal, A. Dhar, Renu Vakil, "Analysis, design and characteristics of X-band dielectric wedge waveguide antennas," pp. 99-102, Microwave J., December 1982.
- [2] T. N. Trinh, J.A.G. Malherbe and R. Mittra, "A metal-to-dielectric waveguide transition with application to millimeter-wave integrated circuits," 1980 IEEE MTT-S International Microwave Symposium, in Washington, D.C., pp.205-207, May 1980.

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